

Lower Passaic River: Geochemical Evaluation of Historical Sediment Data

Presentation to the PDT

May 4, 2005

Ed Garvey, PhD, PG

Malcolm Pirnie Inc.

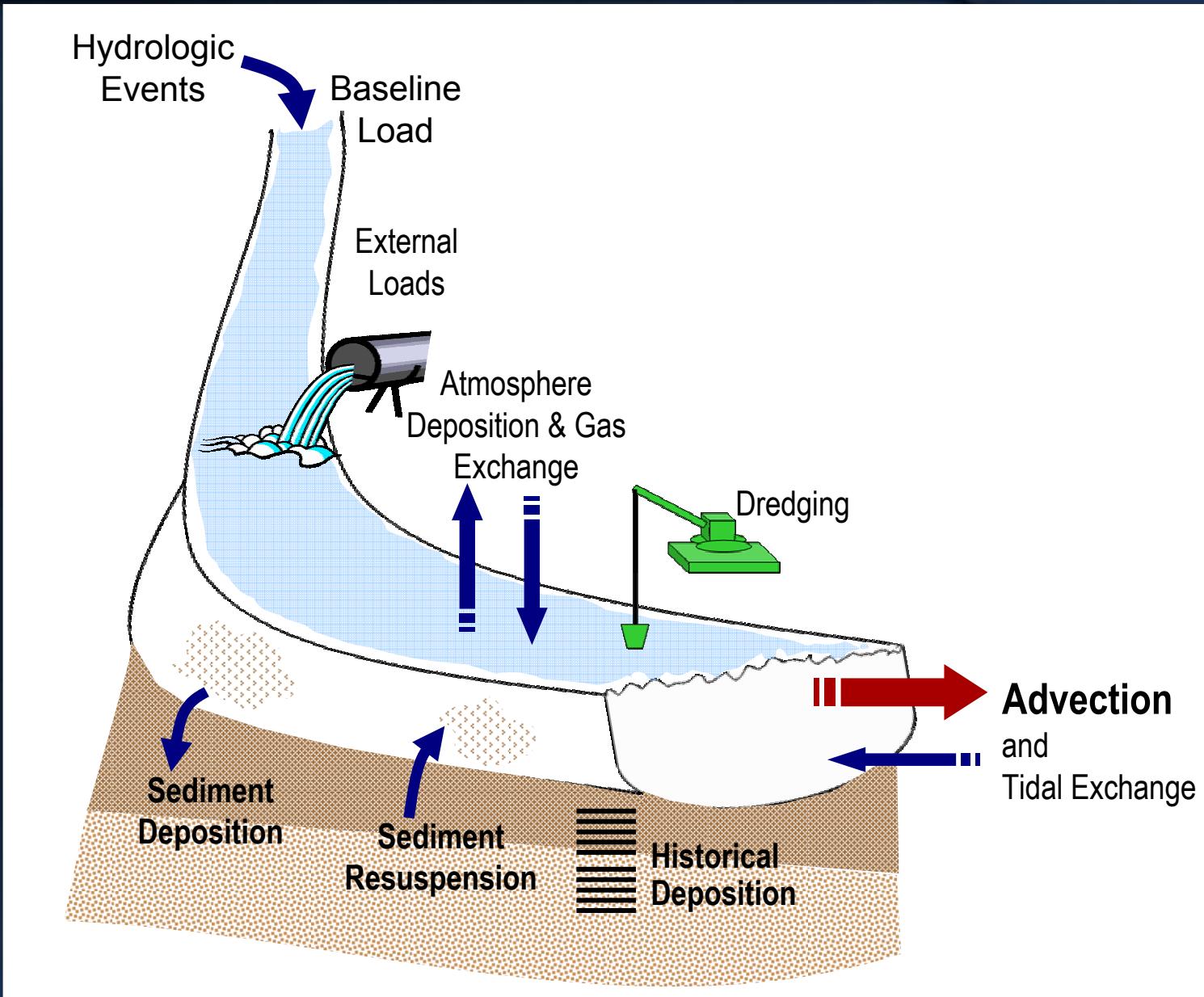
Outline

- Goals of the Initial Analysis
- Geochemical Framework
- Evidence for Sediment Deposition and Stability
- Contaminant Distributions
- Possible Evidence for External Sources
- Summary of Observations

Goals

- Obtain a greater understanding of the processes and loads that govern contamination in the Passaic
- Understand the distribution of contaminants as it relates to these processes

Geochemical Model Framework



Initial Objectives

- Develop components of a Conceptual Site Model
 - Examine sediment stability
 - Examine major contaminant distributions
- Guide future sampling locations

Sediment Deposition and Stability

Sediment Stability

Deposition Rate
Indicators
Cs-137 and Pb-210

Bathymetric
Change

Areas of
Deposition

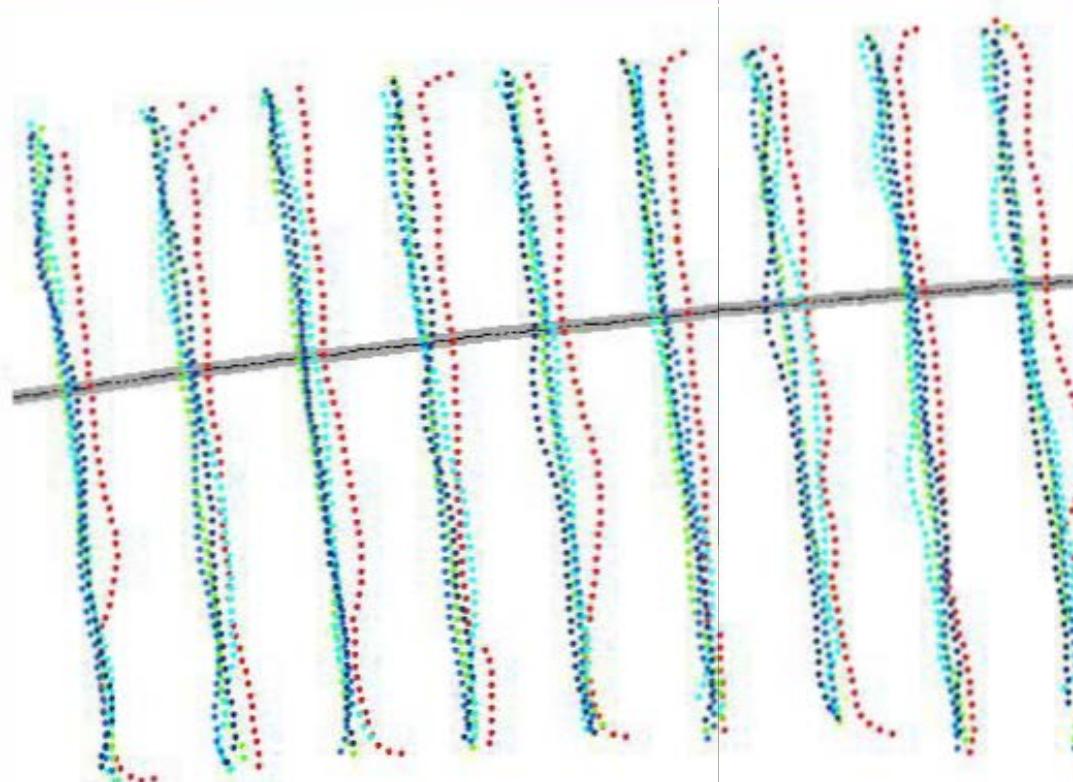
Areas of
Scour

Net Sedimentation

Bathymetric Survey Evaluation

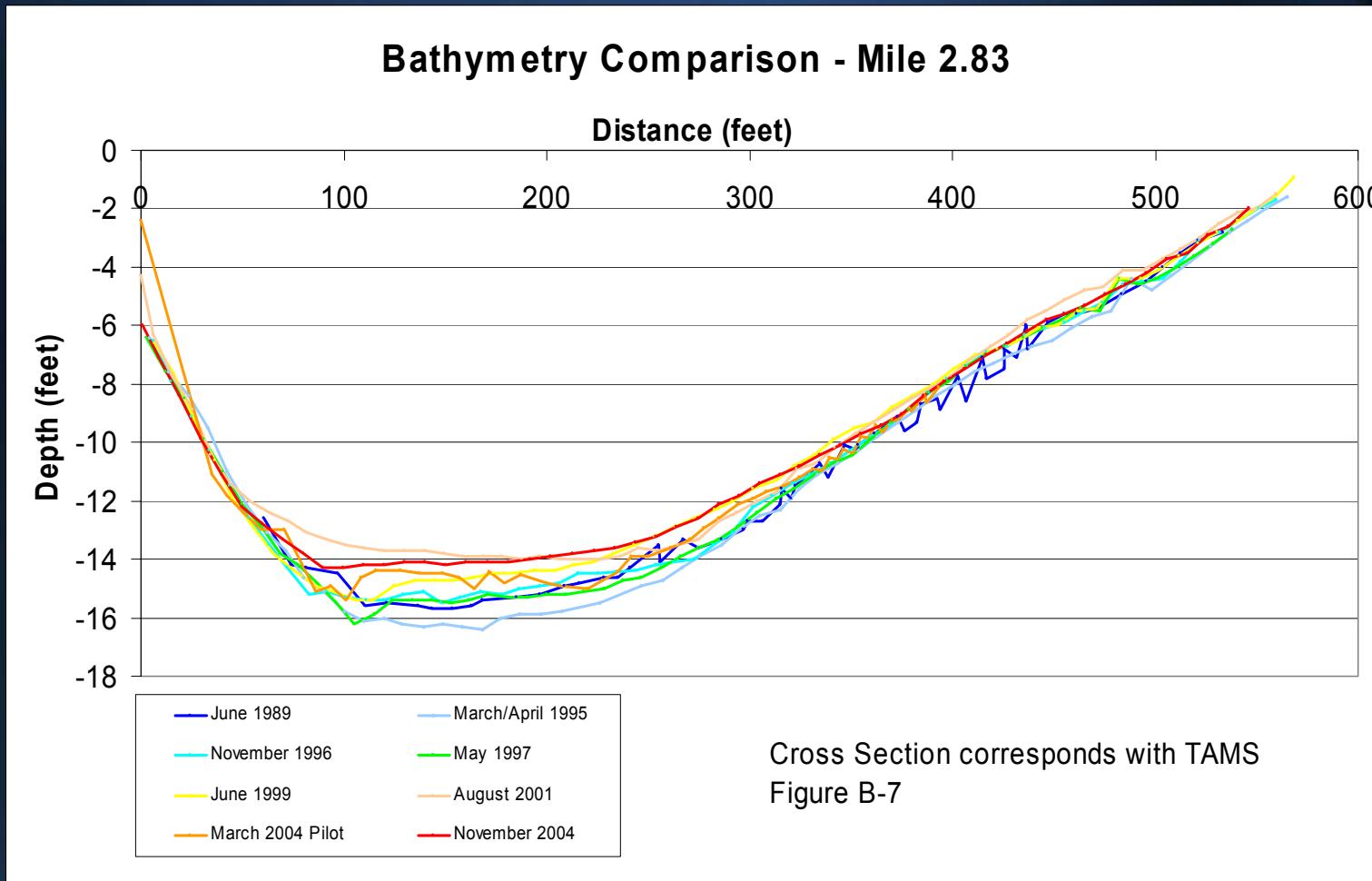
Legend

- 1995
- 1996
- 1997
- 1999
- 2001
- 1989
- March 2004
- November 2004

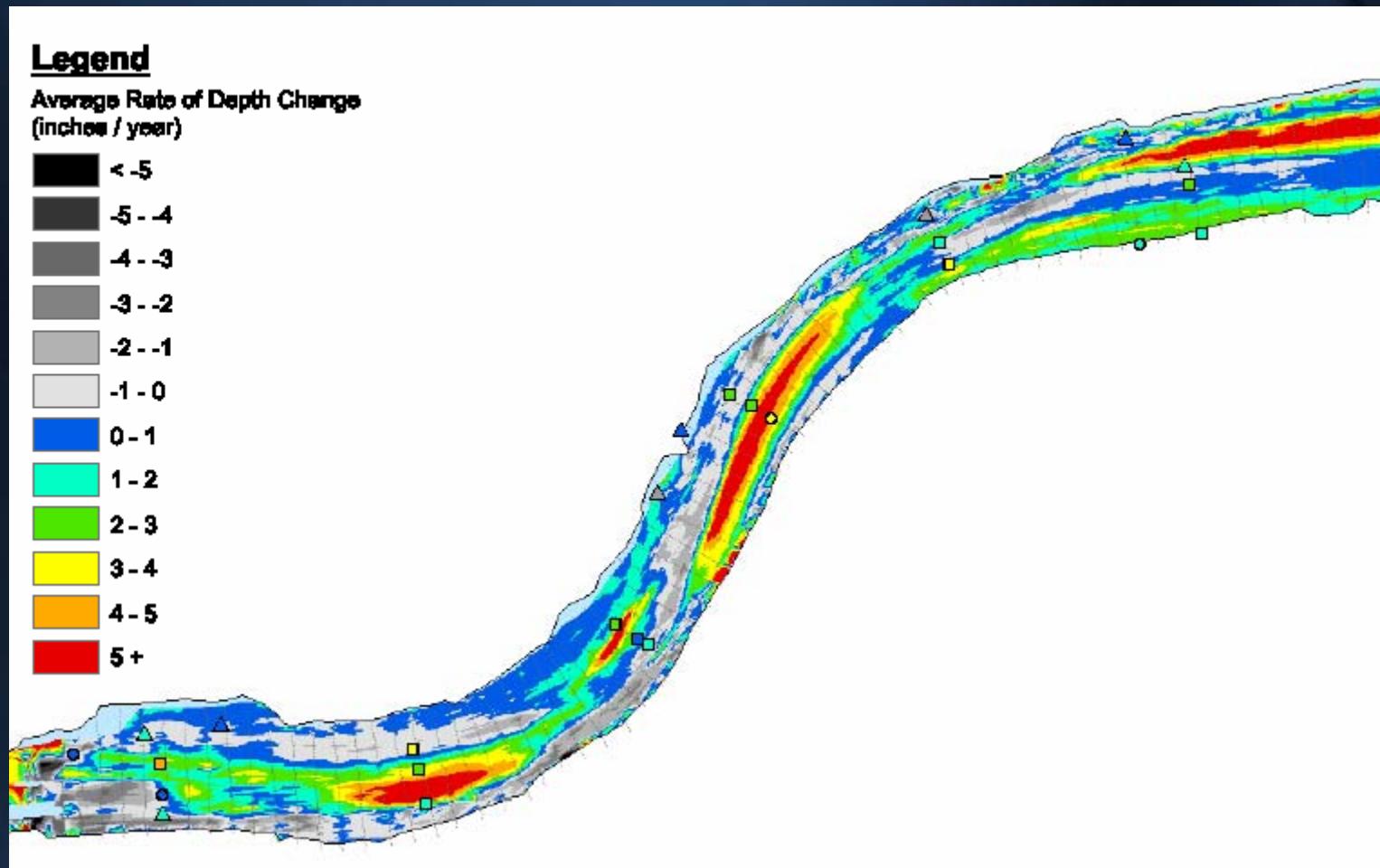


Best Spatial Alignment is for 1995-2001
Transects

Bathymetric Comparison: RM 2.83



Bathymetric Variation Map

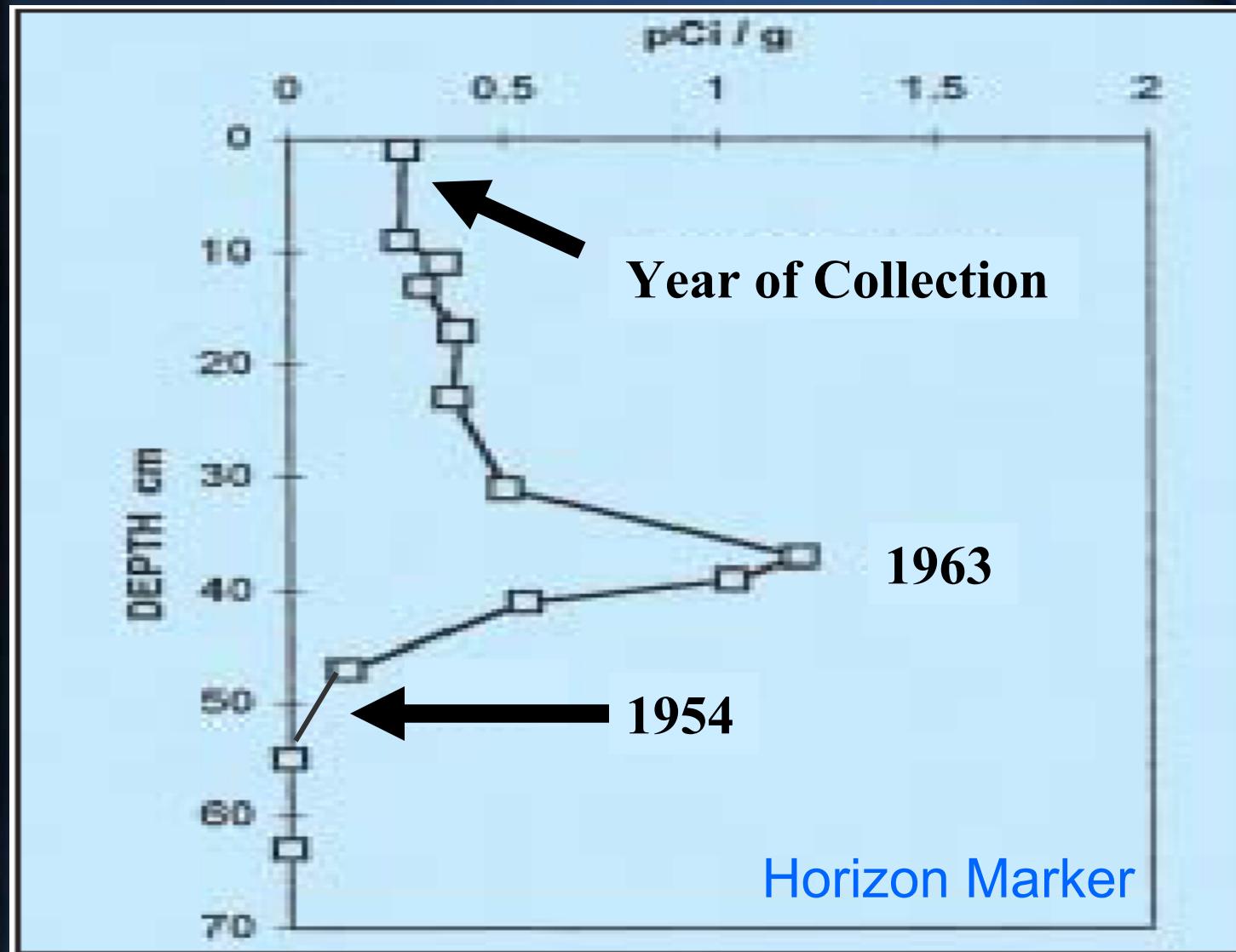


1995 vs. 2001

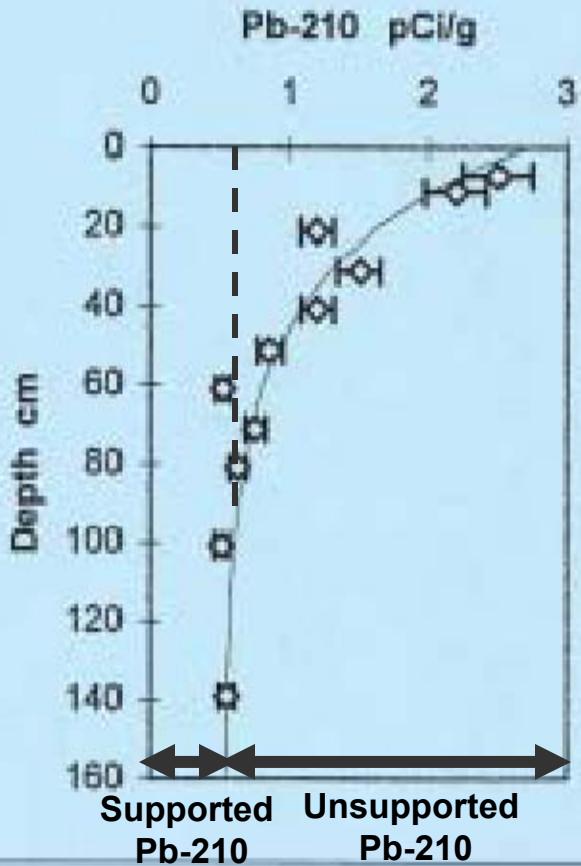
Radionuclide Analysis

- Cs-137 and Pb-210 (as Po-210) exist for nearly 100 cores collected in 1995
- Core profiles reflect a range of conditions from rapid deposition to the absence of sedimentation
- Cs-137 and Pb-210 yield similar rates of accumulation within a core

Ideal Cs-137 Profile

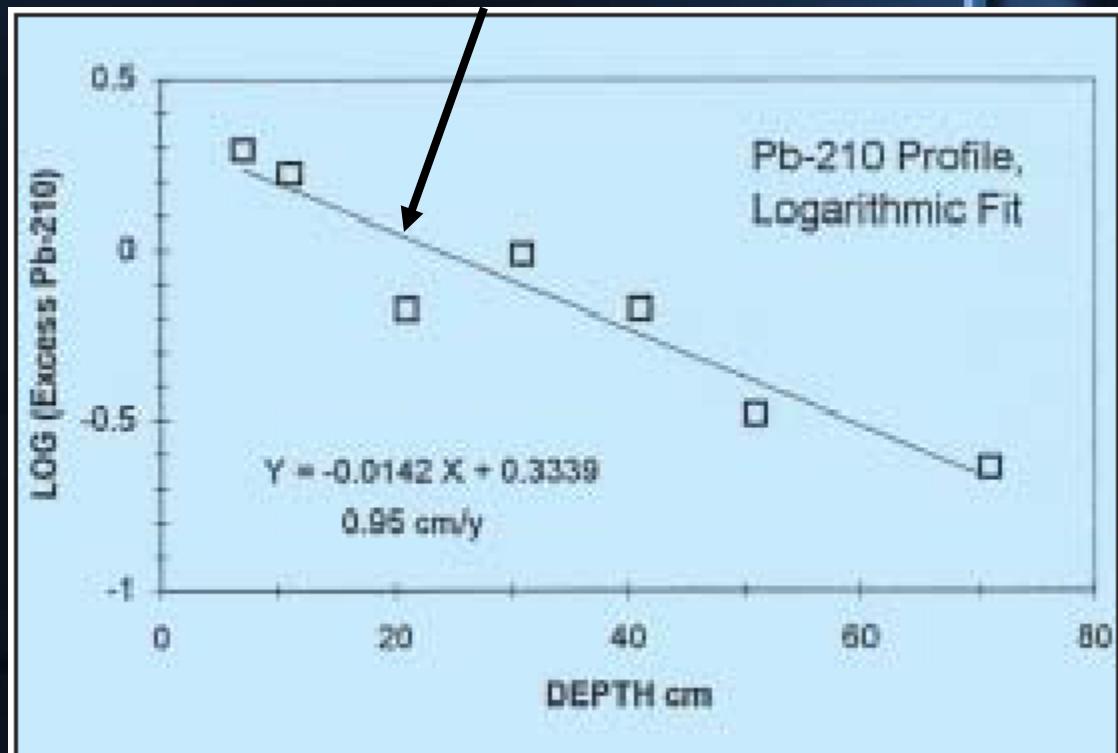


Ideal Pb-210 Profile

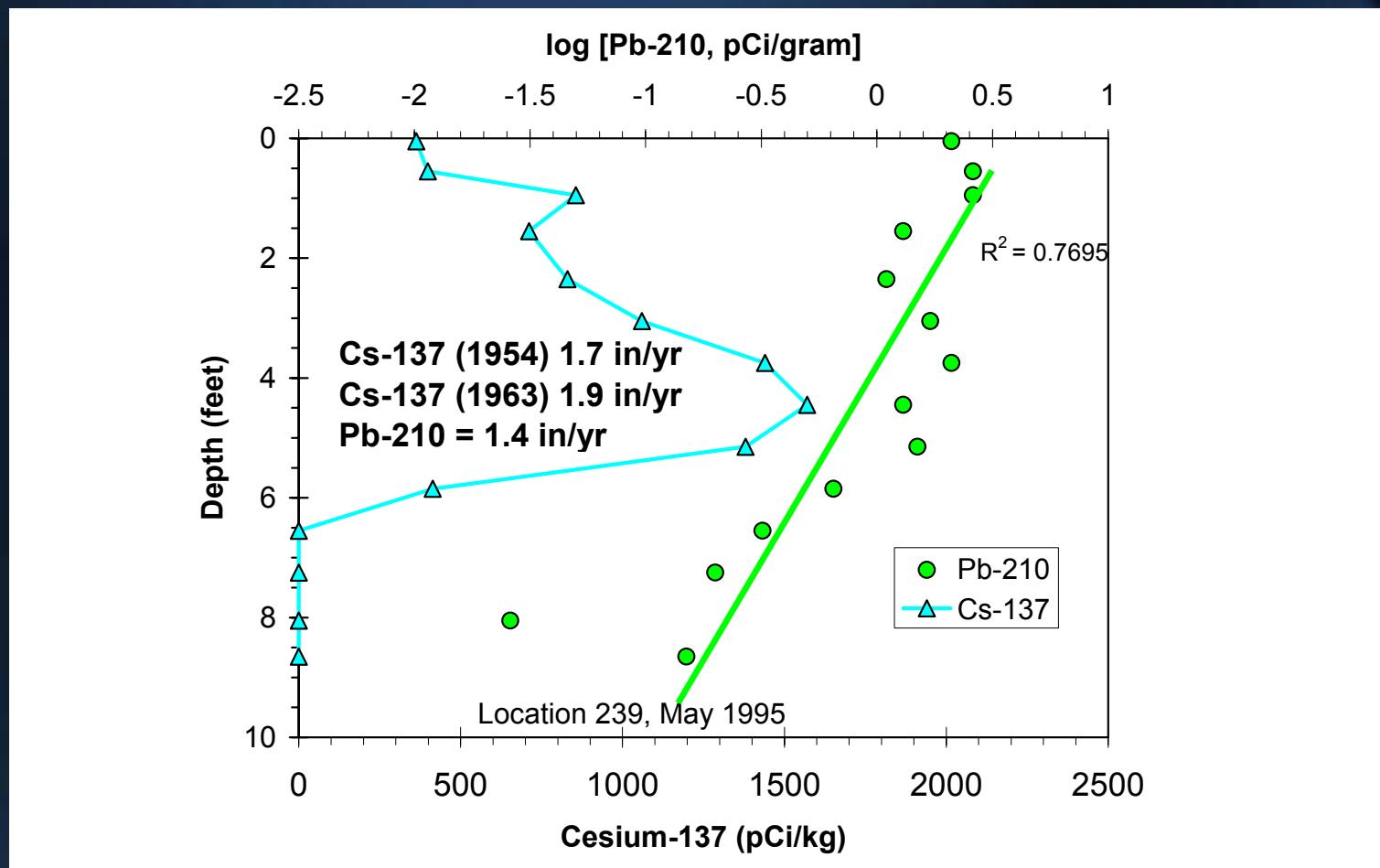


Sediment “Clock”

Slope of line yields
rate of deposition

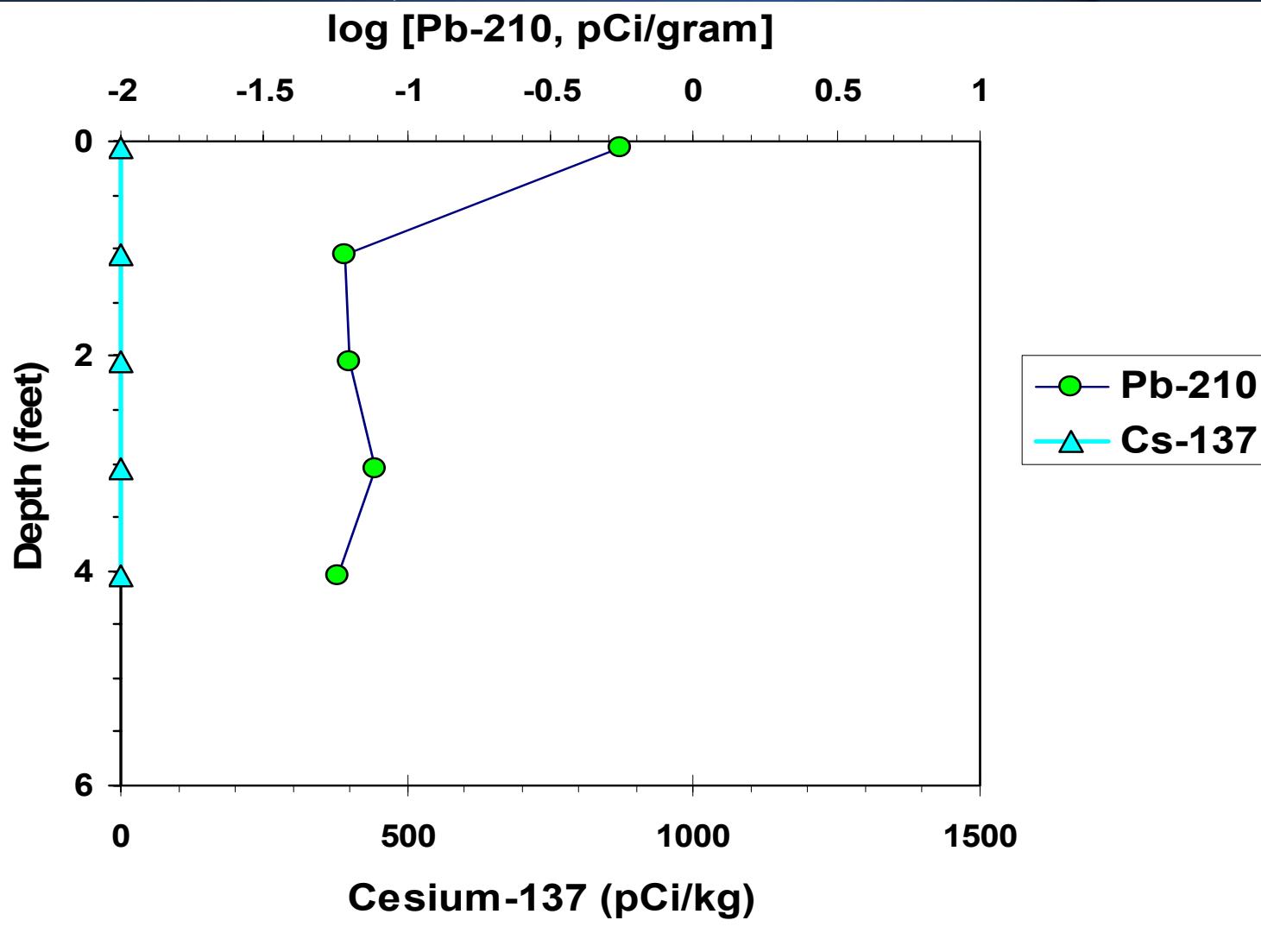


Depositional Site Location 239, 1995:



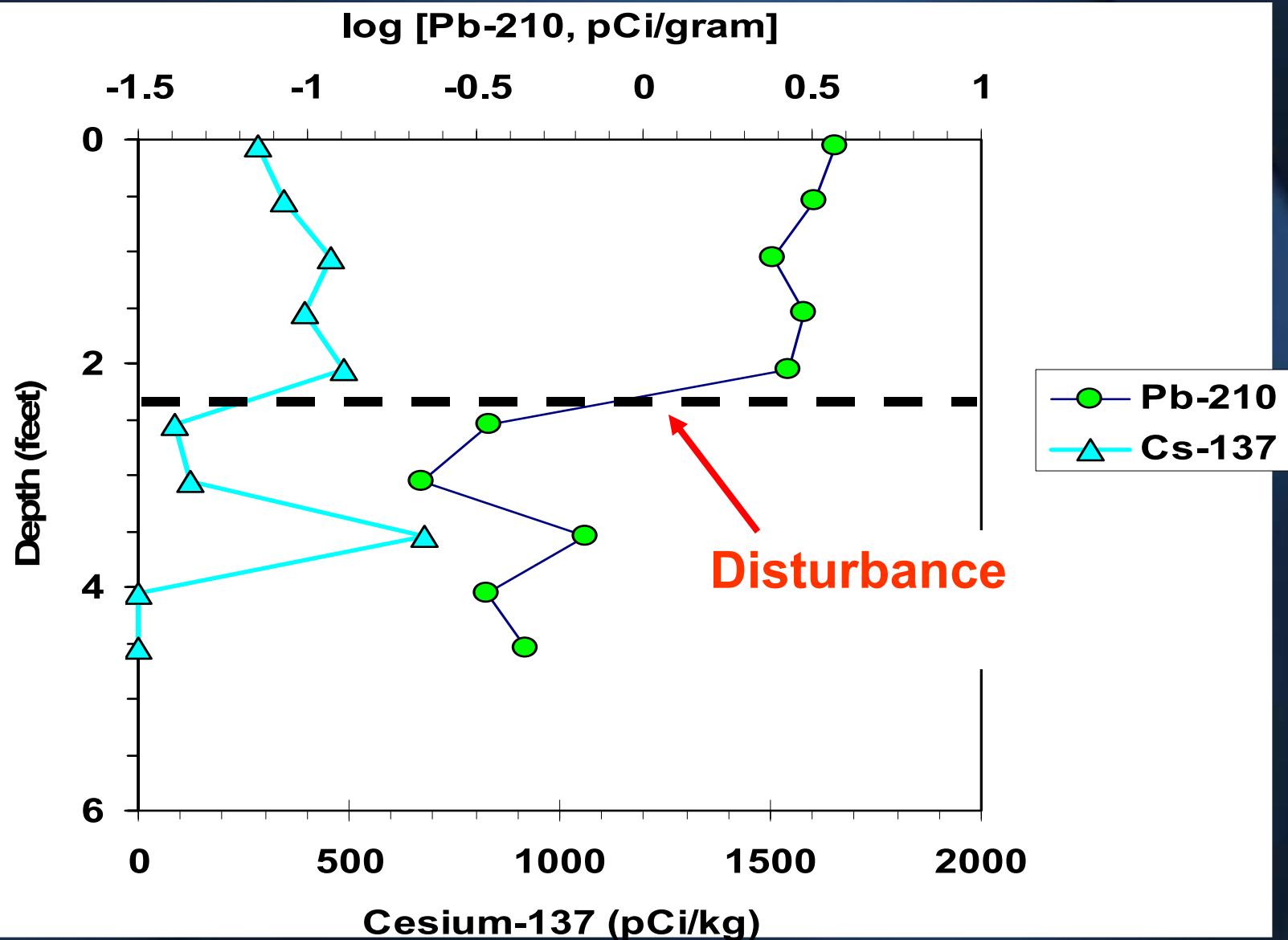
Non-depositional Site

Location 189, 1995: RM 4.47



Disturbed Site

Location 206, 1995: RM 4.5

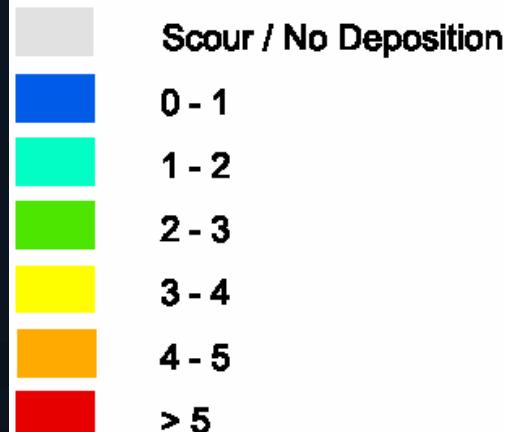


Comparing Bathymetry and Radionuclide Analyses

Change in Bathymetric Surface was converted to a Sedimentation rate for areas with Deposition

Legend

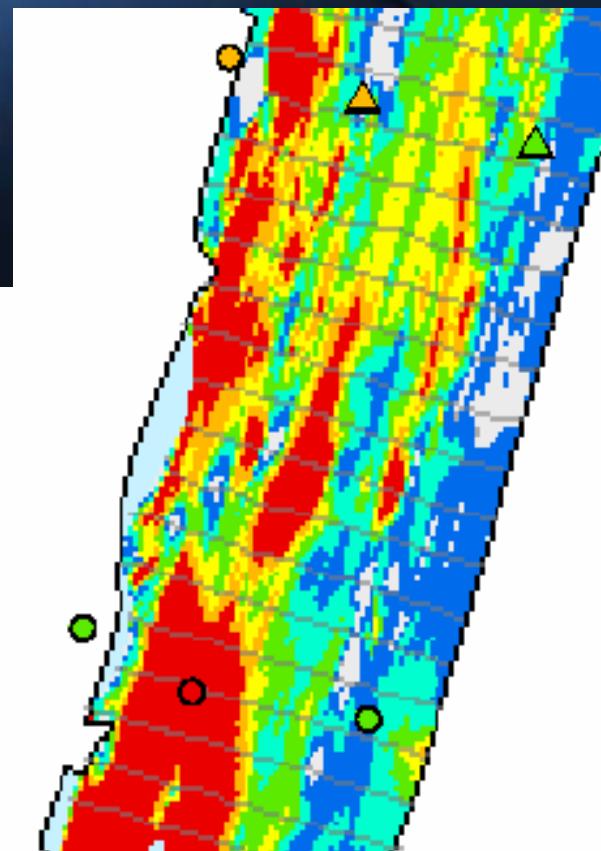
Average Sedimentation Rate (inches / year)



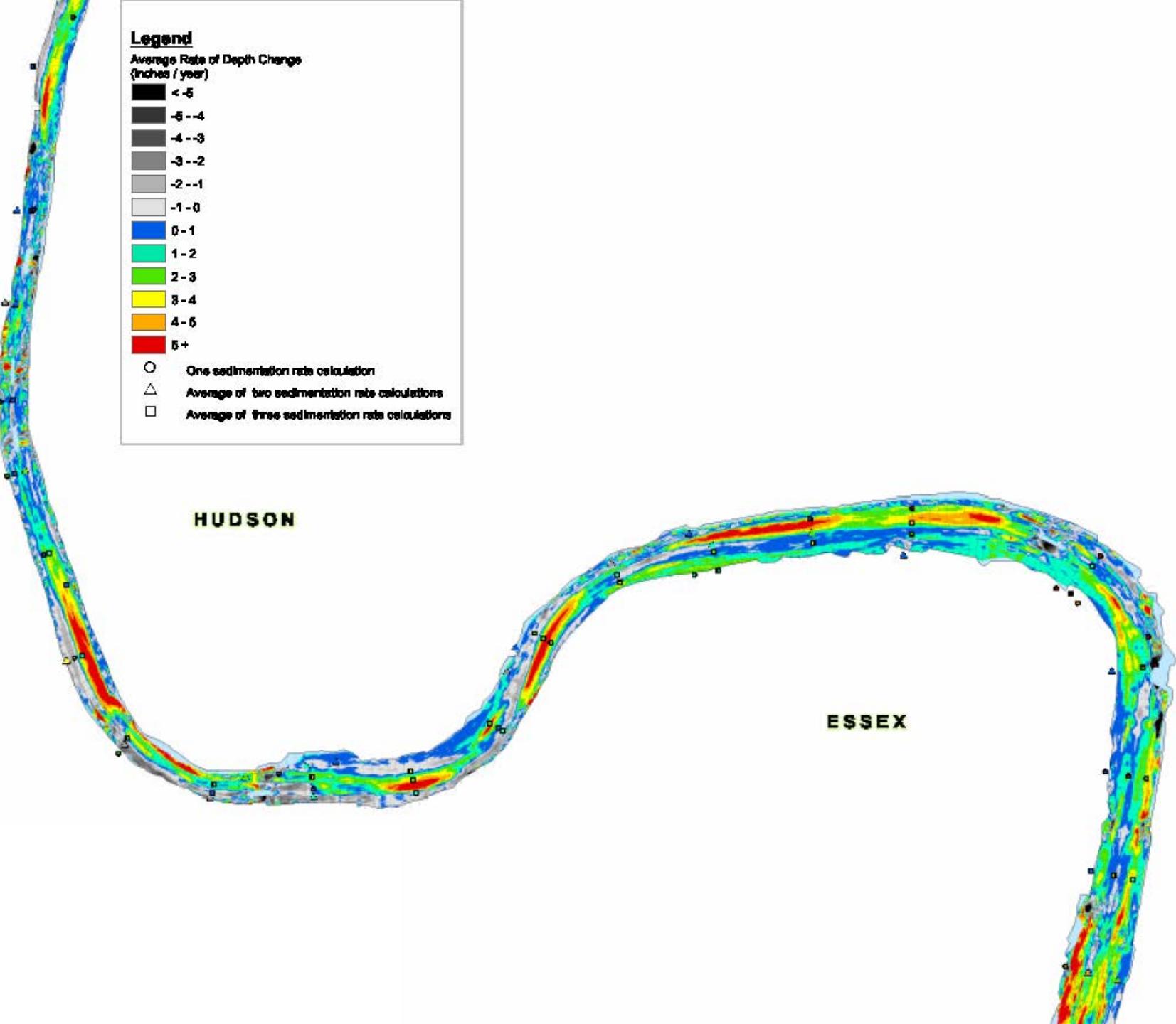
○ One sedimentation rate calculation

△ Average of two sedimentation rate calculations

□ Average of three sedimentation rate calculations

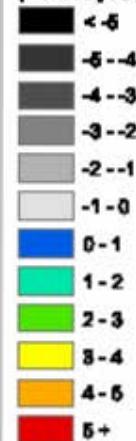


Bathymetric Comparisons



Legend

Average Rate of Depth Change
(inches / year)



- One sedimentation rate calculation
- △ Average of two sedimentation rate calculations
- Average of three sedimentation rate calculations

HUDSON

ESSEX

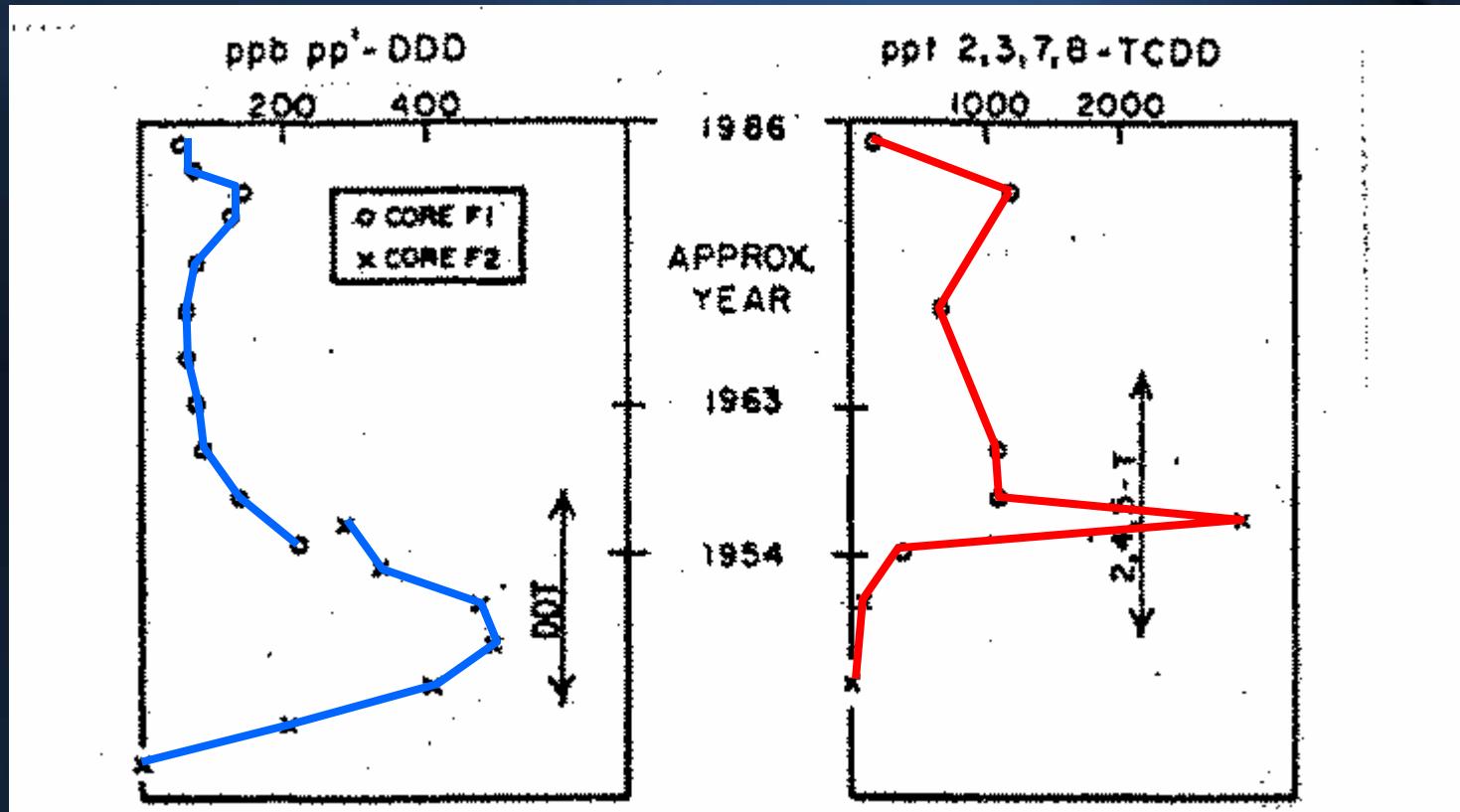
Contaminant Analysis

- DDT
- Dioxins (2,3,7,8-TCDD)
- Mercury
- PAHs

2,3,7,8-TCDD and DDT

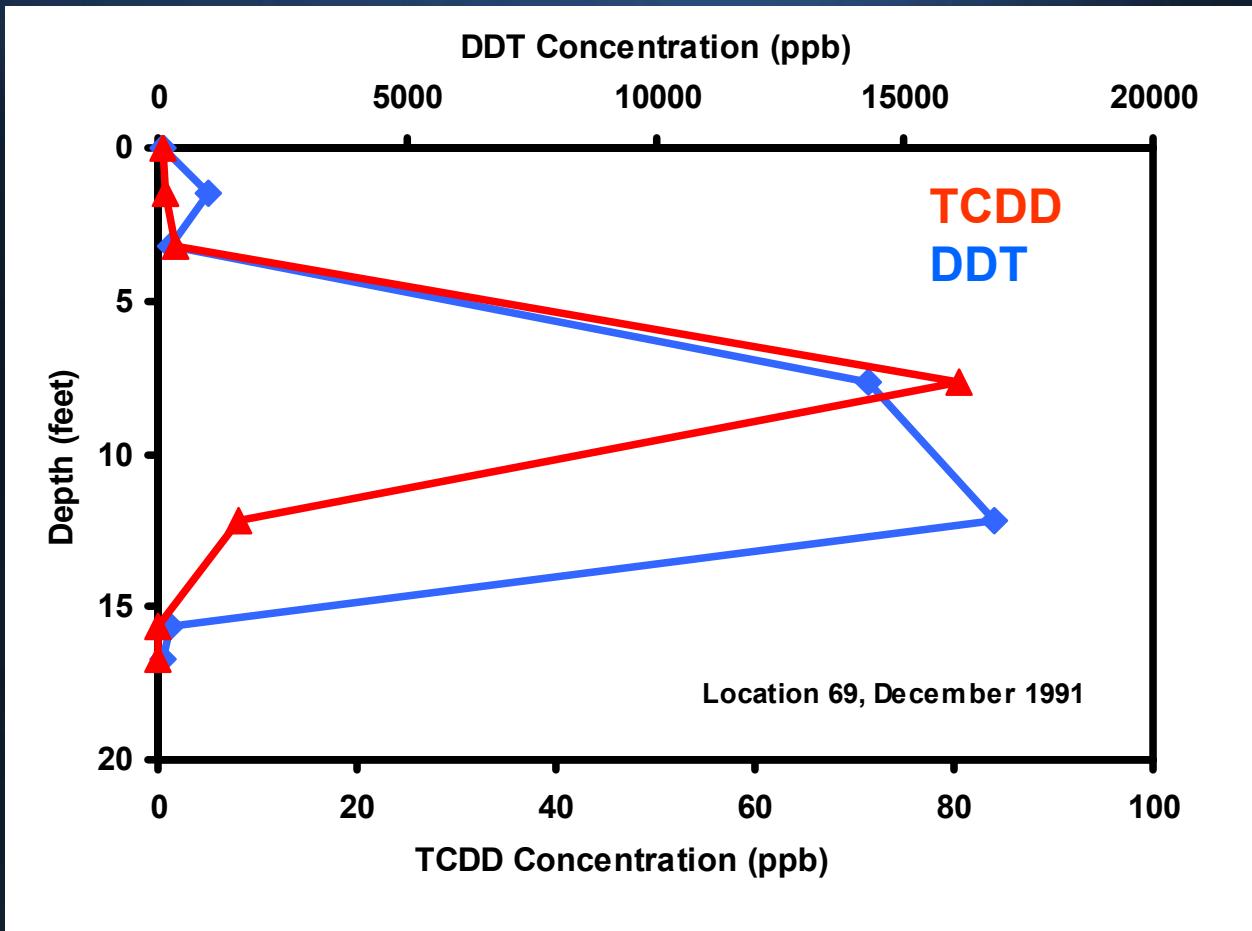
History of Contamination

Bopp et al. (1991) - Newark Bay Core F



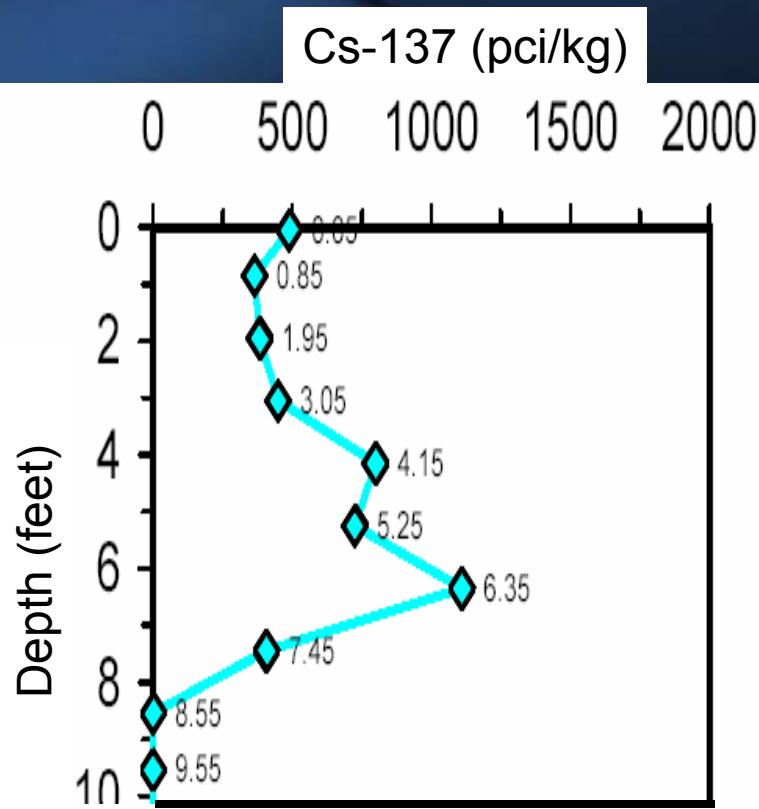
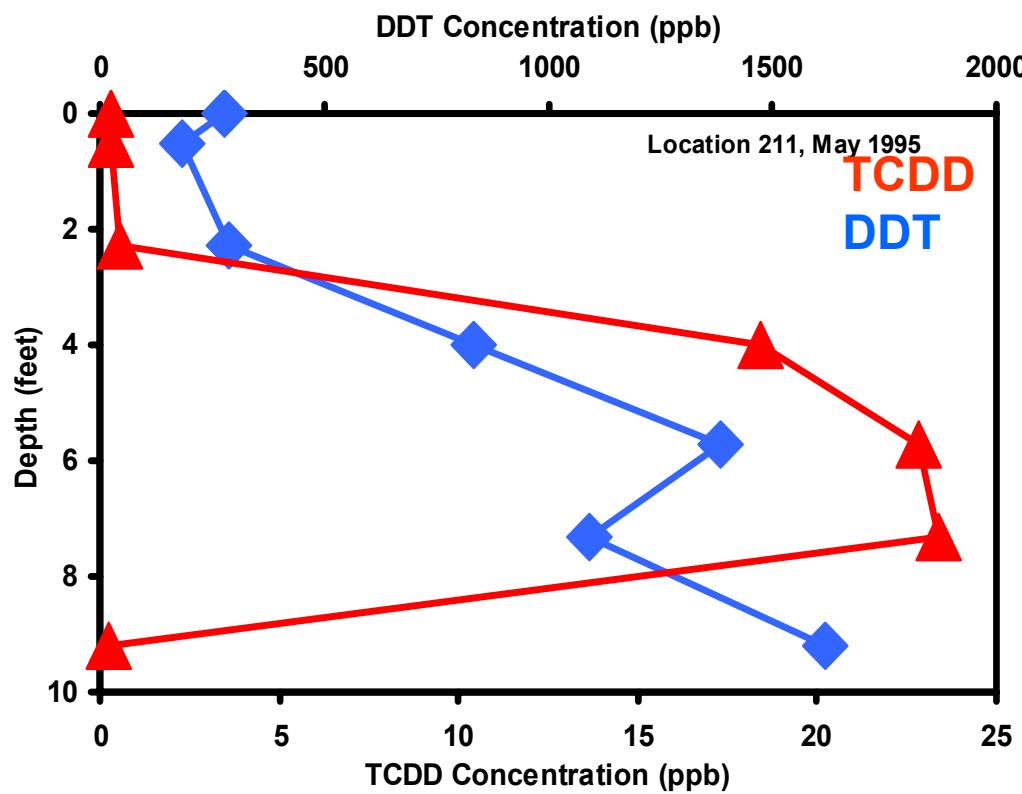
DDT predates 2,3,7,8-TCDD

Deep Passaic Cores Are Consistent with Bopp's Observations in the Passaic



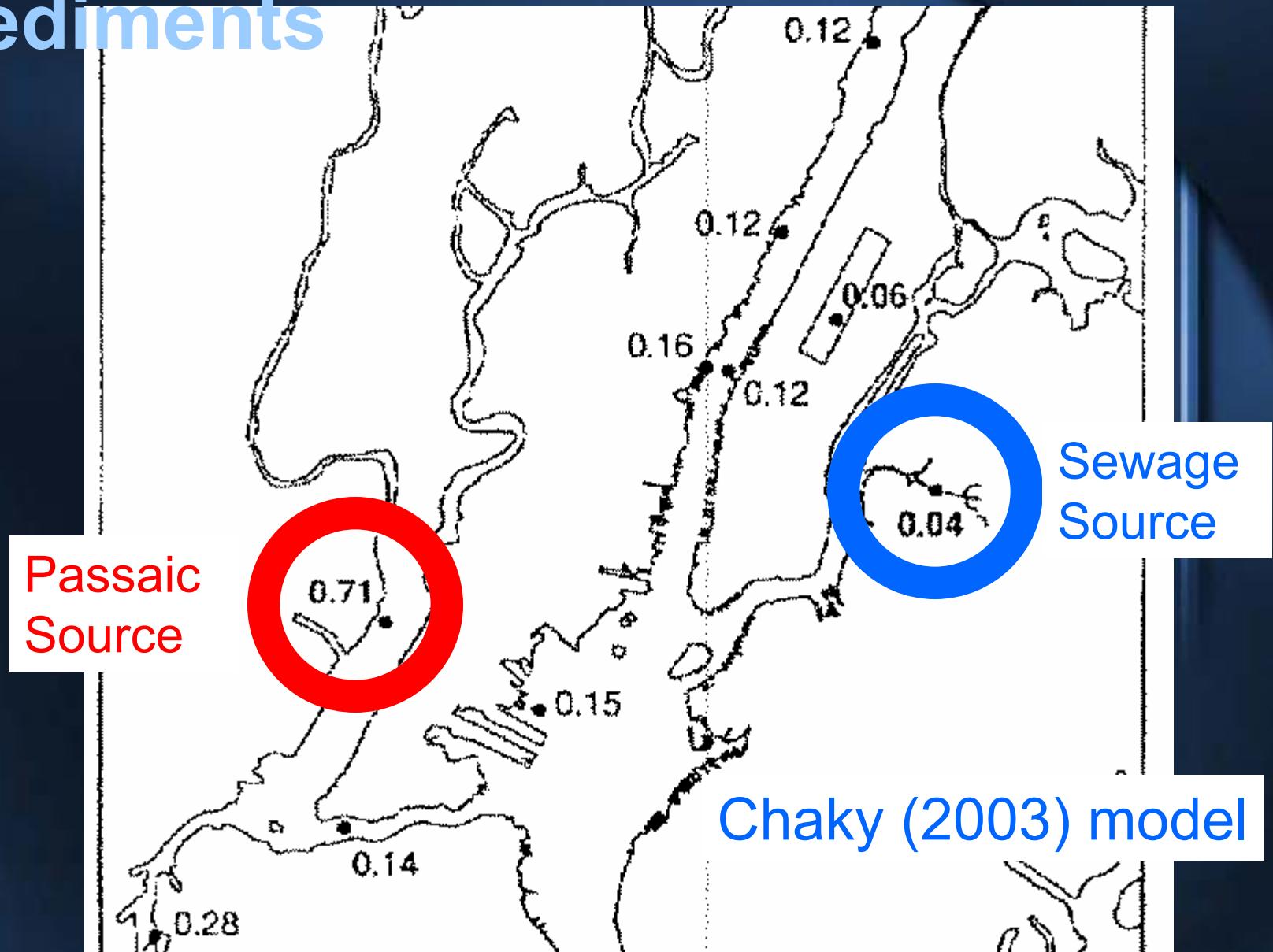
1991 Core, RM 3.5

Shallow cores are consistent with this history

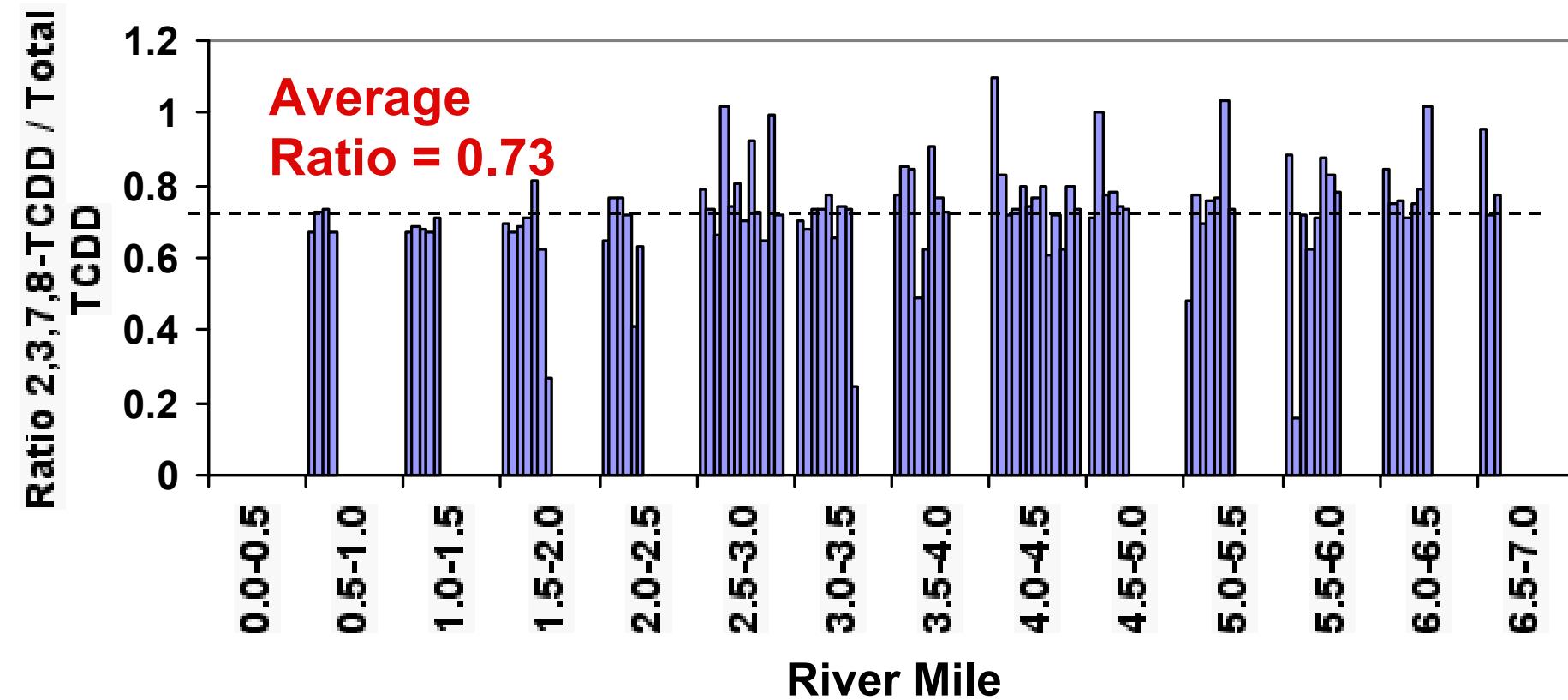


1995 Core, RM 3.78

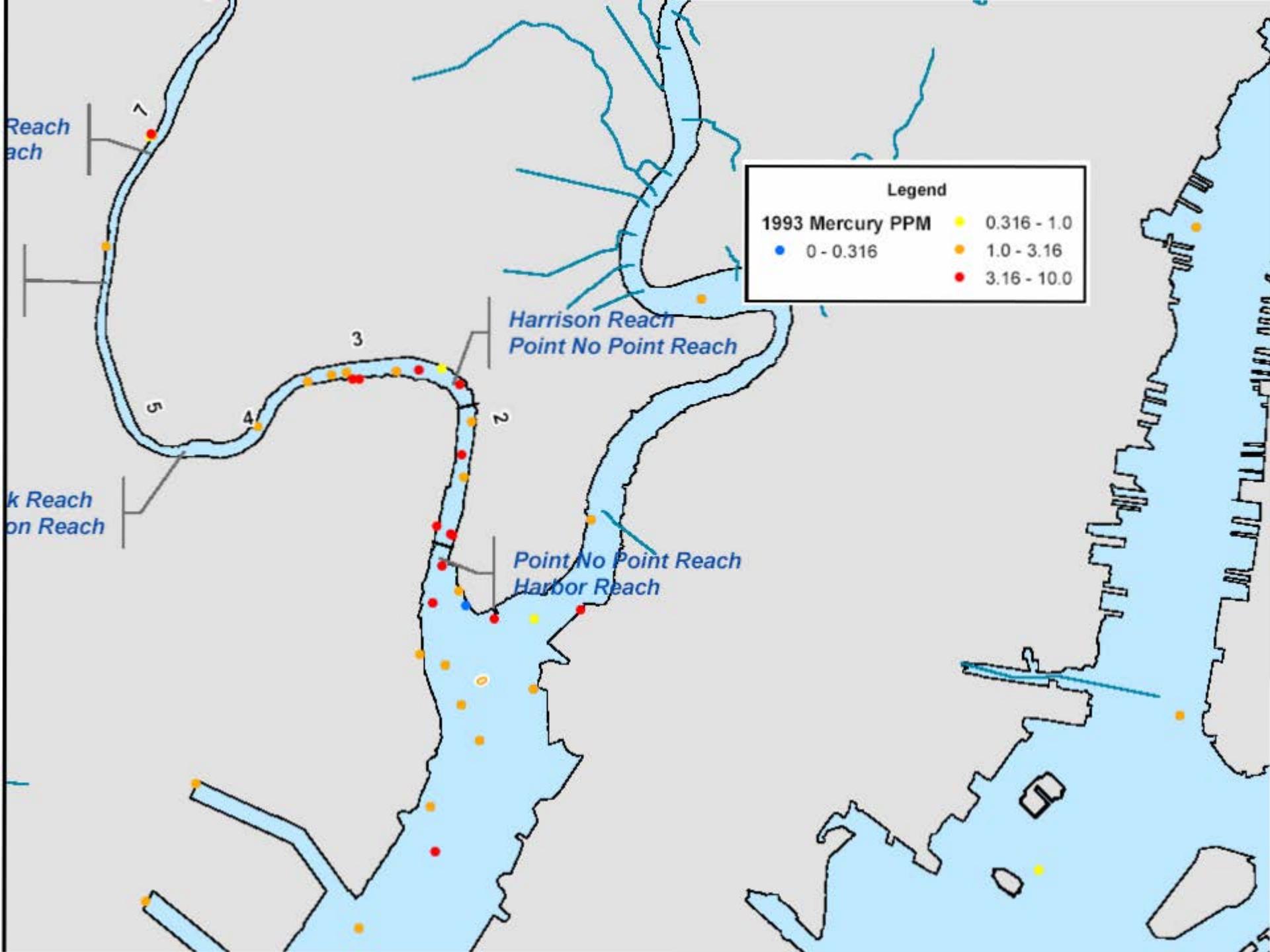
2,3,7,8-TCDD/Total TCDD in Harbor Sediments

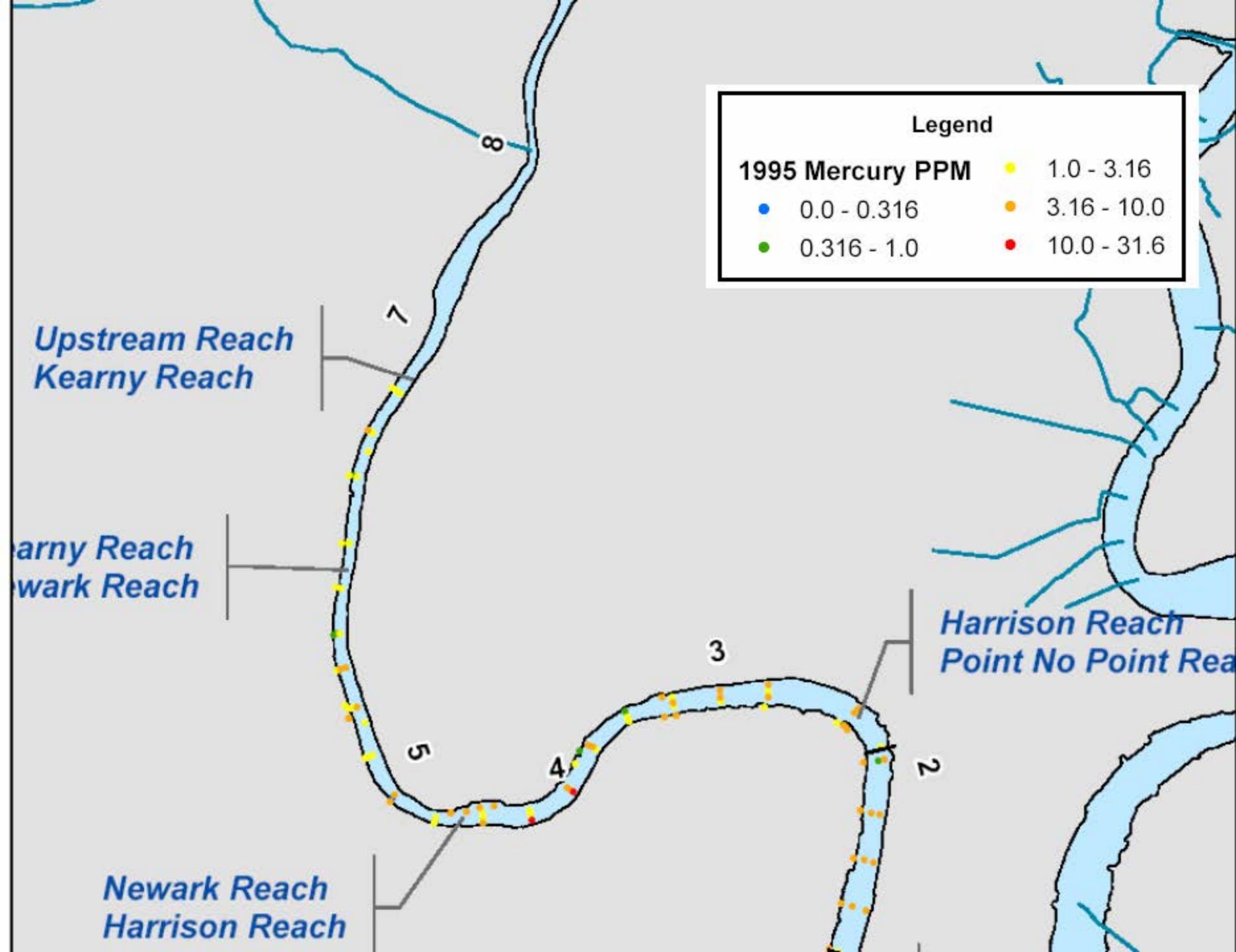


Passaic River Surface Sediments Have the TCDD Source Ratio

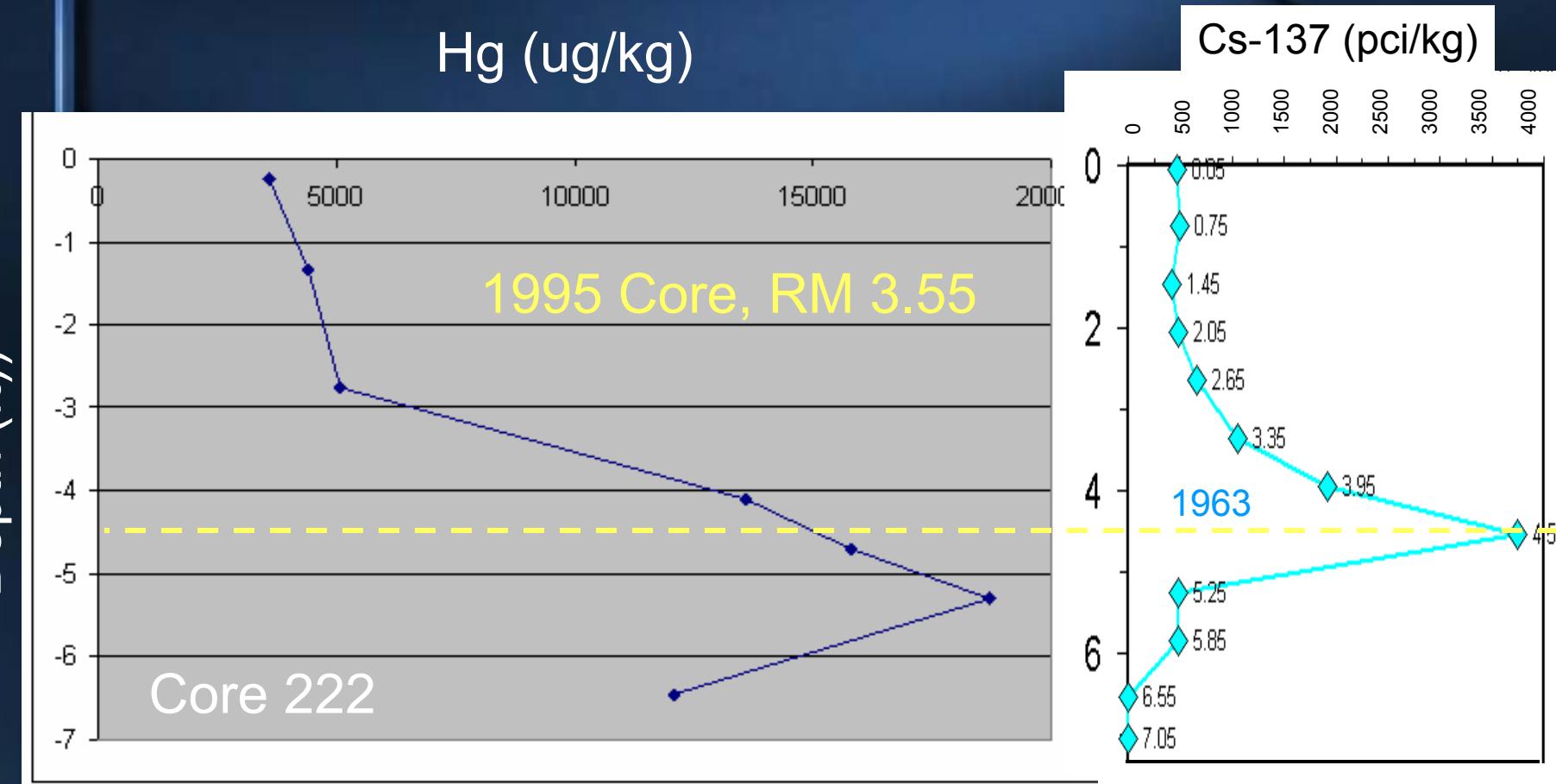


Mercury





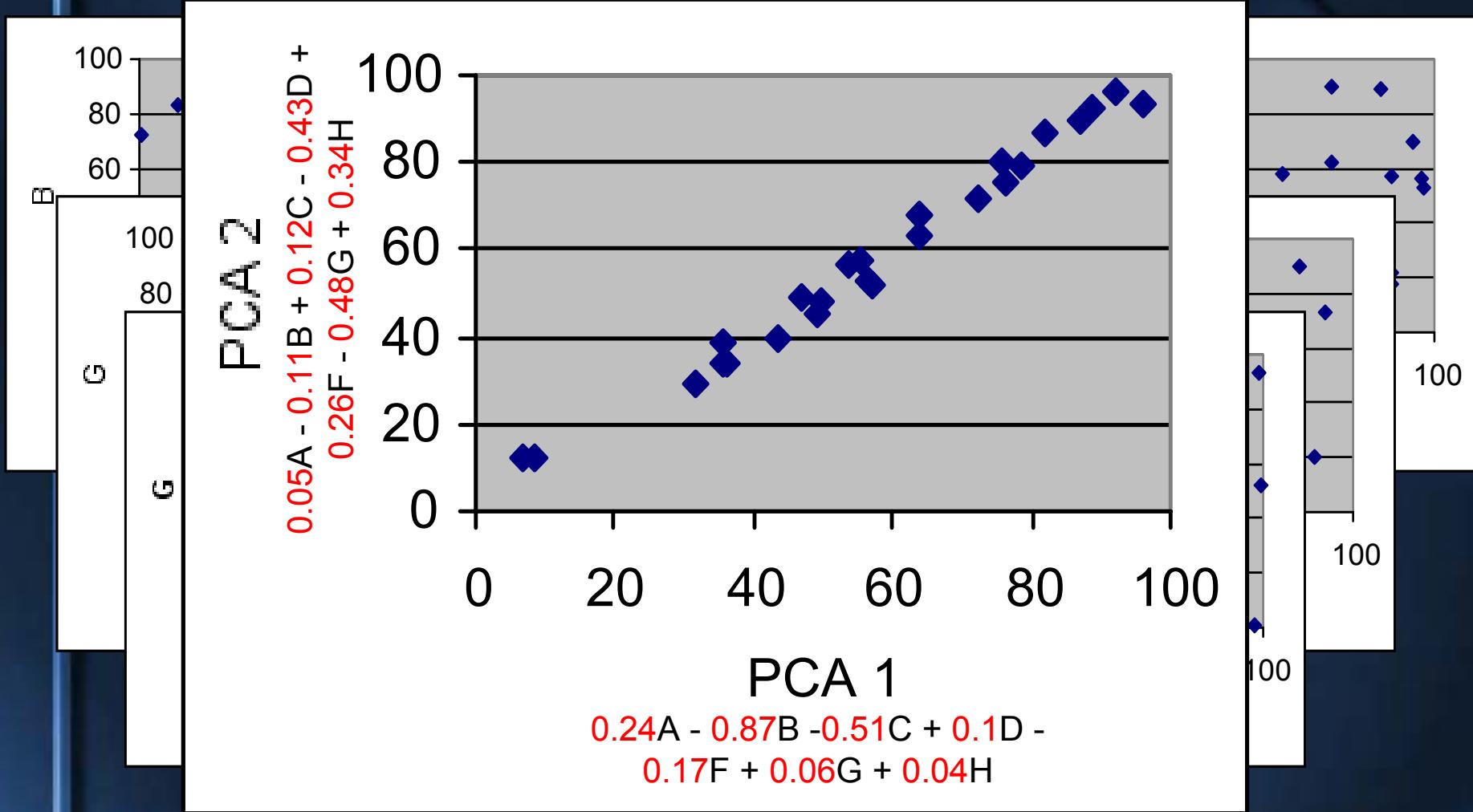
Mercury Depositional History



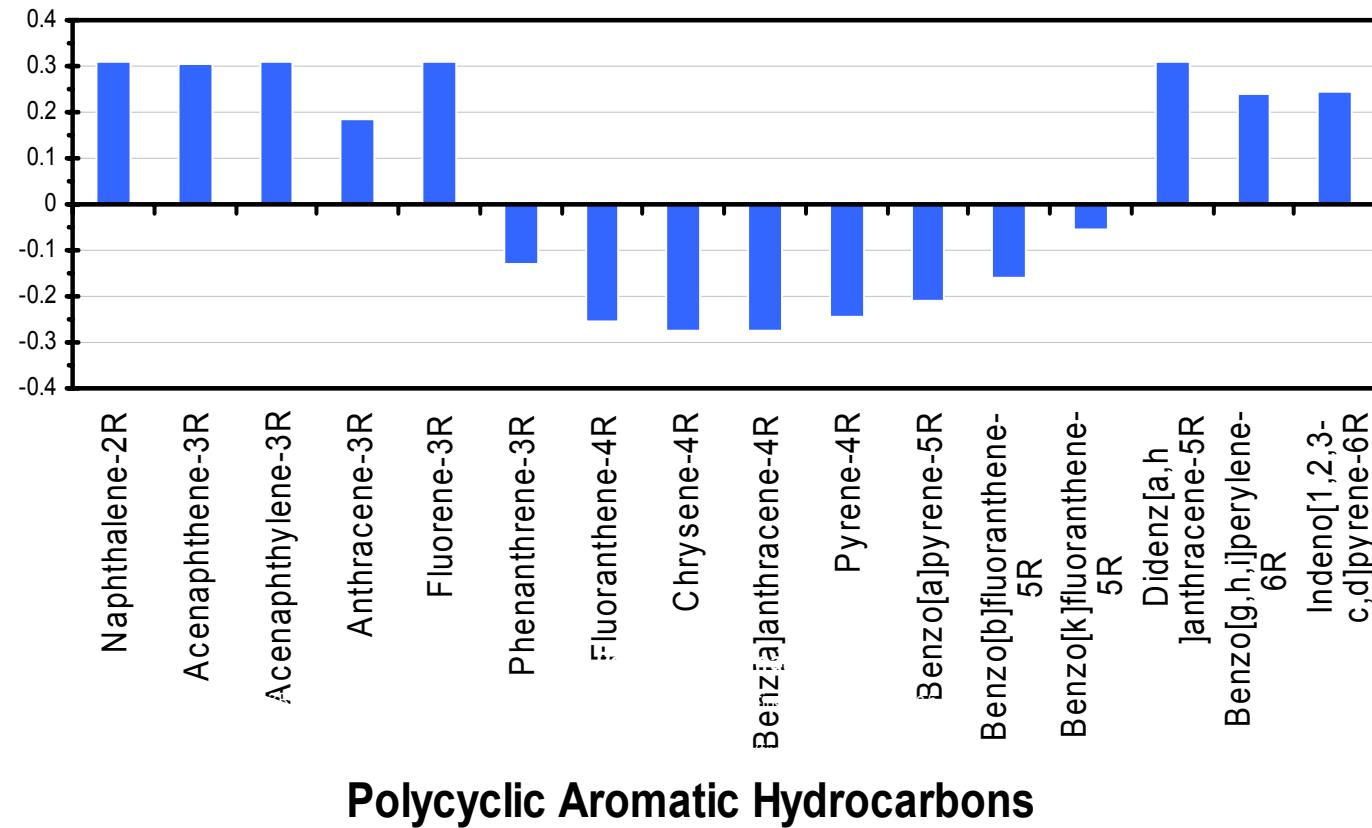
- Hg maximum discharge occurs in early 1960s.
- Surface concentrations remain elevated.
- Significant inventory at depth.

PAHs

What Are Principal Components?

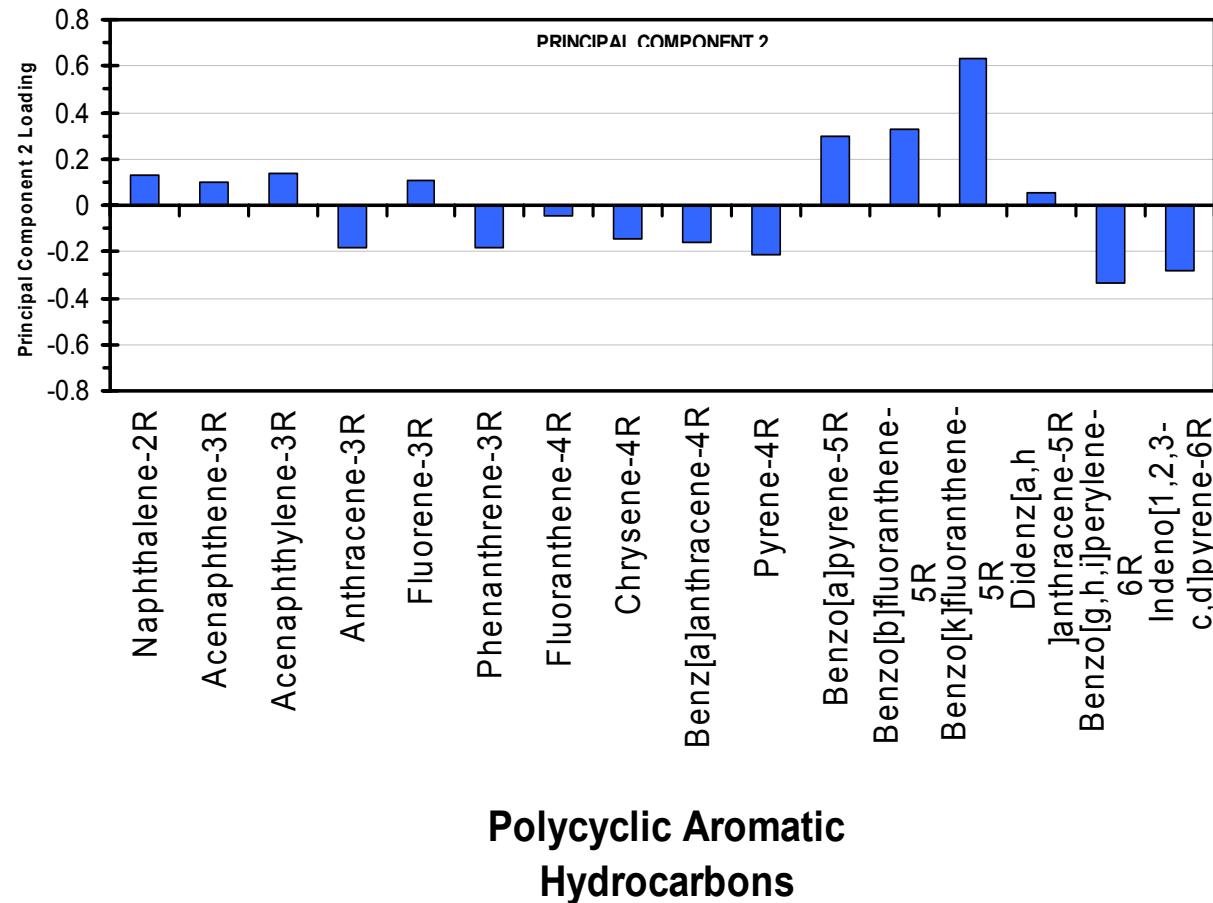


Principal Components Analysis for PAHs

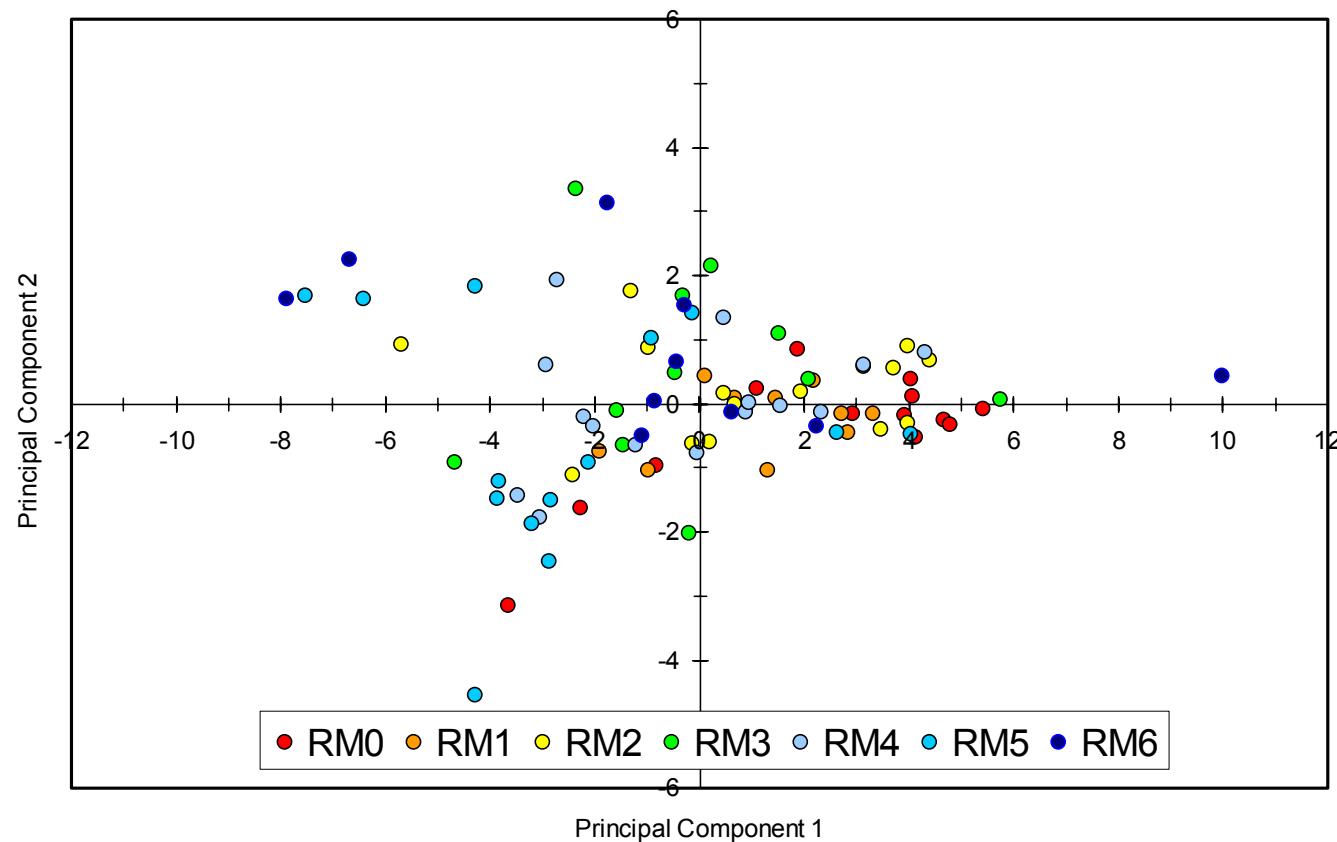


First component clearly linked to molecular structure

Second Component Less Useful



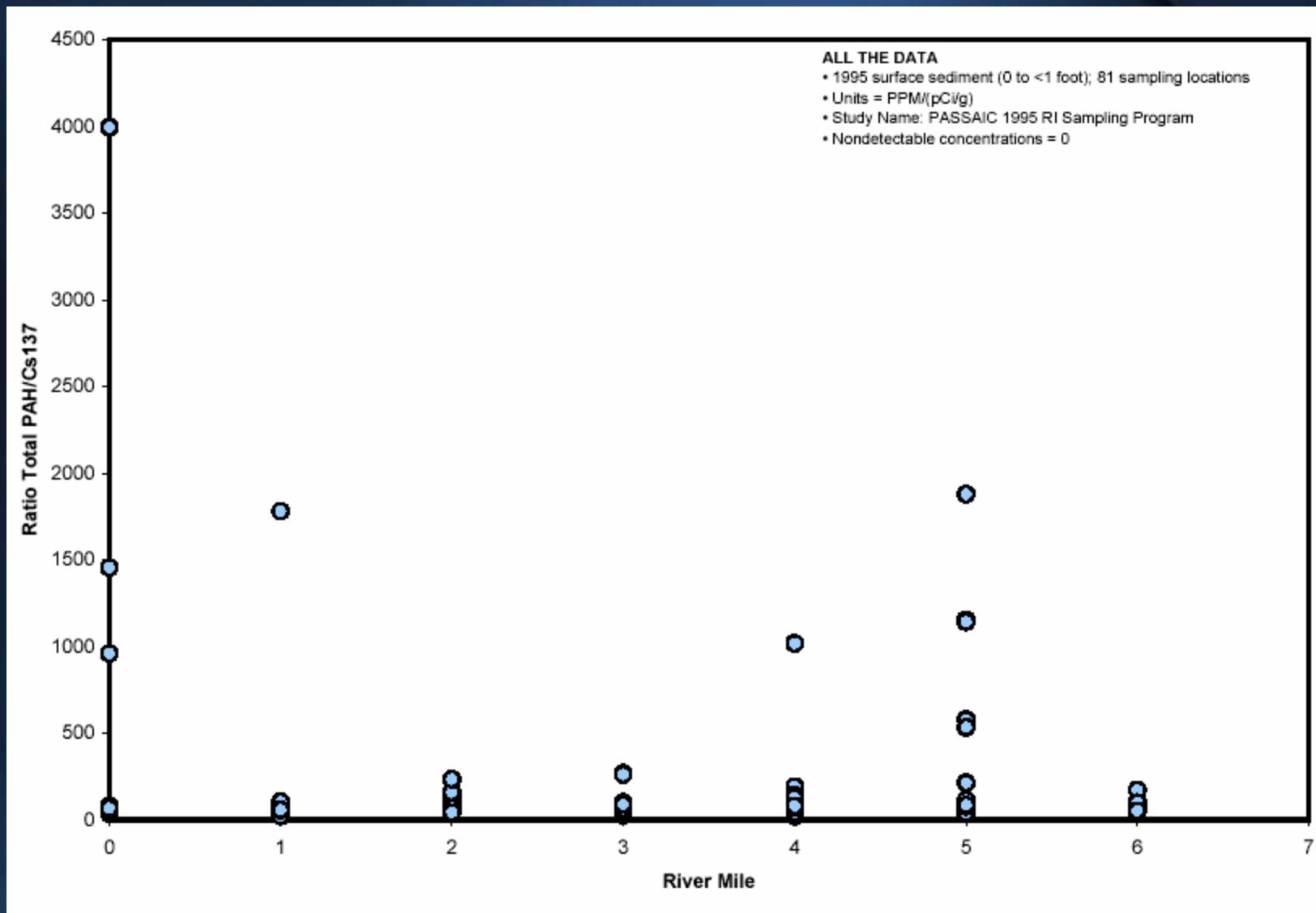
PAH Pattern Correlates with River Mile



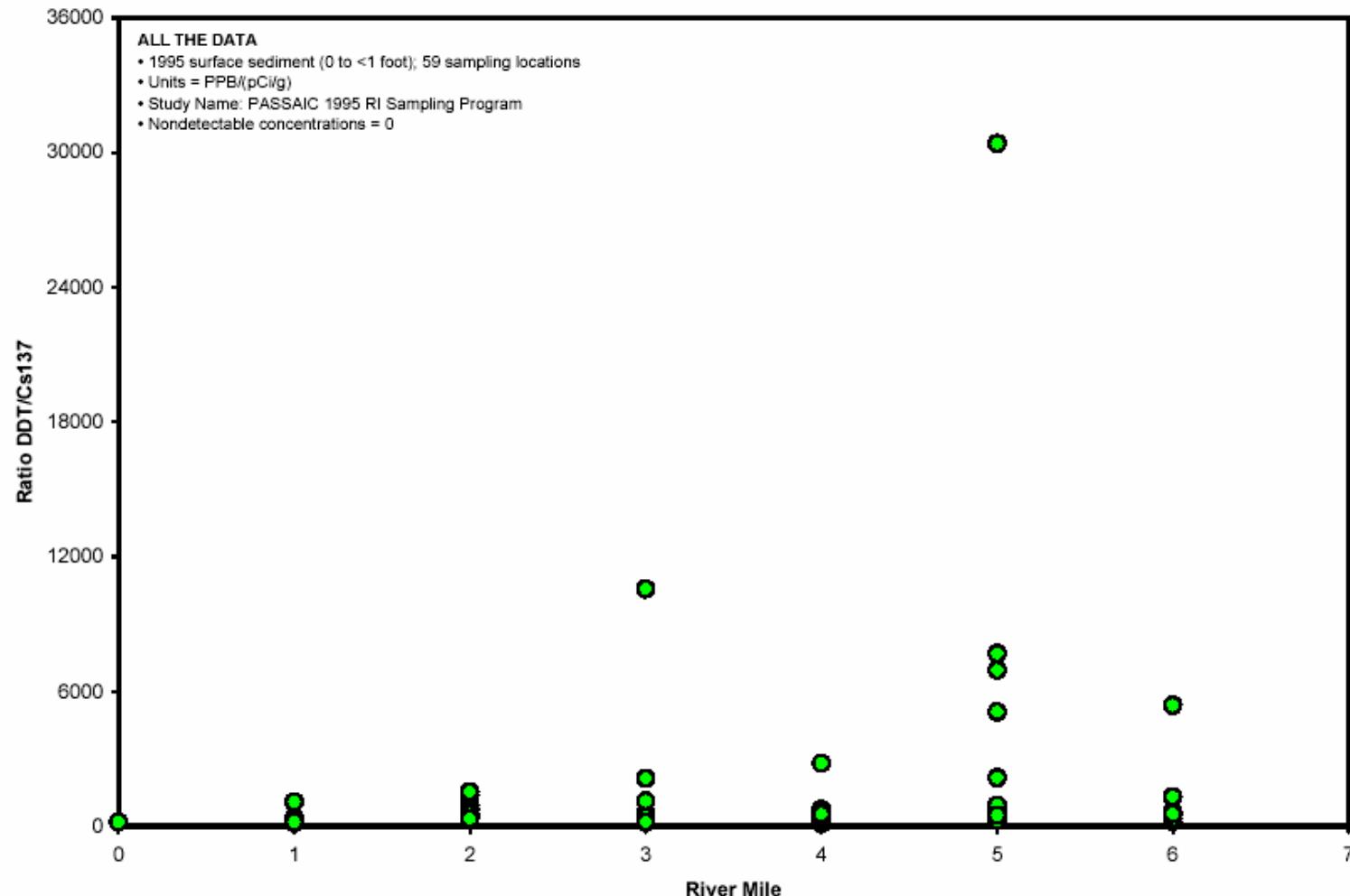
Evidence for External Source(s)

- Ratio of contaminant to Cs-137 can be used to identify external source regions
- Analysis is based on homogeneity of Cs-137 in fine-grained sediments in a given year
- Particle-reactive contaminants will follow Cs-137 dispersion through estuary
- Proximity to source will appear as increase in ratio to Cs-137 since local deposition will accumulate high contaminant levels before dispersion can dilute the impact
- Erosion of older sediments can also cause a ratio change

PAHs vs Cs-137



DDT vs Cs-137



Initial Observations (1)

- A heterogeneous depositional environment exists in the lower 7 miles of the Passaic River.
- This heterogeneity suggests depositional, erosional, and dredging events throughout the river.
- Bathymetric measurements of sedimentation rate appear to coincide with radionuclide measurements of sedimentation rates.

Initial Observations (2)

- The geochronology of a sediment core is a useful tool for understanding sediment transport and the extent of contamination.
 - Radionuclides may be used to establish the depth of contamination
- DDT is well correlated with dioxins and may serve as a surrogate for contaminant delineation and in fate and transport.

Initial Observations (3)

- 2,3,7,8-TCDD/Total TCDD is diagnostic of the Passaic source, suggesting the absence of other significant sources.
- Mercury contamination is extensive and suggests local sources
- Evidence for sediment transport to Newark Bay from radionuclide and chemical contaminant data. Results consistent with Bopp et al. (1991) and Chaky (2003).

Initial Observations (4)

- Cs-137 results suggest source areas near RM 5 and 1
- PAH patterns suggest at least 2 PAH sources
- Strong surface concentration gradients suggest minimal sediment transport upstream from Newark Bay

Acknowledgements

- Solomon Tugbawa
- Cindy How
- Carolyn Zeiner
- Manali Desai
- Terri Akbas
- Erika Zamek
- Amy Marie Accardi-Dey
- Stephanie Cedro
- Janis Karn
- Amita Patel